

Review

# Adjunctive Effects of Diode Laser in Surgical Periodontal Therapy: A Narrative Review of the Literature

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**Abstract:** The surgical procedures in the treatment of periodontitis generally aim to reduce pocket depth, improve teeth maintenance, and enhance long-term stability. Several approaches have been proposed over the years including different techniques, drugs, and medical devices, with the main purpose to minimize the surgical procedure and improve both the outcomes and patient compliance. Among all the medical devices proposed in surgical and non-surgical periodontology, different laser wavelengths (e.g., Erbium: YAG, Erbium: CR, KTP, Diode) have been studied worldwide but generally with inconsistent results. Nowadays, the diode laser is one of the most used lasers among general dentists, also promoted as an adjunctive therapy in periodontology, mainly in non-surgical procedures. This study aims to review data emerging from the literature on the use of diode lasers and adjunctive therapy to the conventional periodontal surgery. This research was conducted using PubMed and Scopus search engines with a combination of relevant keywords, including “Surgical Periodontal Therapy”, “Periodontal Surgery”, “Periodontal Regenerative Surgery”, and “Surgical Treatment for Periodontal Disease” in combination with “Diode Laser”, “Diode-Driven Laser”, and “Diode Emission Laser”. Selected articles were carefully reviewed to identify studies reporting data on the effectiveness of diode lasers in periodontal surgery. Results of the current review suggest potential clinical benefits of diode laser-assisted periodontal surgery, as studies reported improvements in key parameters such as clinical attachment level (CAL), bleeding on probing (BOP), and plaque index (PI) postoperatively. Additionally, VAS scores, indicative of post-surgical discomfort, were lower for laser-treated sites, and a short-term reduction in periodontal pathogens was observed. However, the clinical outcomes significantly differ across the studies, and the evidence does not uniformly support a superior effectiveness of diode lasers as an adjunctive tool in surgical periodontology. While the data indicate that diode laser use may contribute to enhanced periodontal health and possibly accelerate healing in some cases, these findings should be interpreted cautiously, as further research, possibly multicentric and in large numbers but mandatory with well-defined protocols (stage of periodontitis, preliminary non-surgical procedures and results, laser wavelength and protocol of use, post-operative maintenance, follow-up clinical and radiological criteria) are surely needed to possibly validate the observations emerging from the current review and eventually to standardize clinical protocols in the future. Such limitations have been well addressed in this paper and are clearly discussed and essentially related to the focus on the total uncertainty of the literature and general caution.



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## 1. Introduction

Therapeutic strategies for periodontal disease are designed to prevent tissue loss and promote the regeneration of damaged tissue. The use of laser technology in recent years, mainly diode lasers, has opened new paths for improving clinical outcomes in several fields of dentistry, including periodontal therapy [1,2].

Diode lasers emit coherent light through semiconductors, confirming their versatility and precision; their main features include the capability to operate at different wavelengths, typically between 810 and 1064 nm, allowing clinicians to effectively treat both soft and hard tissues [3]. The diode laser offers excellent control during all surgical procedures and minimizes thermal damage to the surrounding tissues if appropriately used, thus reducing intraoperative bleeding as well post-operative pain and edema. Also, the diode laser has well recognized antibacterial properties that improve postoperative healing and reduce infections [4–6]; the latter property may also help in disinfecting root canals, theoretically improving the success of endodontic procedures, and decreasing the different bacterial strains associated with peri-implantitis, such as *A. actinomycetemcomitans*, *P. gingivalis*, *P. intermedia*, *T. denticola*, *T. forsythia*, *F. nucleatum*, and *C. rectus* [7].

In addition, the diode laser is widely used in the management of oral ulcerated lesions of different etiology by the property of photobiomodulation, offering pain reduction and promoting faster healing [8,9]. Several studies have examined the efficacy of the diode laser as a supplementary tool in non-surgical periodontal treatment [10], as the ability to penetrate deeply into soft tissues may enable the effective decontamination of periodontal pockets and root surfaces, reducing bacterial load and promoting a more conducive environment to tissue regeneration [11,12]. This may also occur by photobiomodulation, which increases cellular activity, promoting fibroblast proliferation as well as collagen synthesis [13]. Although still controversial in the literature, several studies support non-surgical diode laser-assisted periodontal therapy as effective in improving periodontal clinical parameters such as a reduction in probing depth and gain of clinical attachment [14]. Some studies suggest that the use of a diode laser may enhance the effects of traditional regenerative therapy and contribute to improved long-term outcomes [11,12,15].

This review aimed to evaluate the applications of diode lasers described in the literature in association with surgical periodontal therapy, focusing on the protocols utilized and their reported outcomes.

## 2. Materials and Methods

A comprehensive literature search was conducted on PubMed and Scopus databases to identify relevant studies related to the role and applications of a diode laser in periodontal surgery as an adjunct. The search was performed using a combination of keywords and Medical Subject Headings (MeSH) terms, including (Surgical Periodontal Therapy [Mesh] OR (Periodontal Surgery) OR (Periodontal Regenerative Surgery) OR (Surgical Treatment for Periodontal Disease)) AND ((Diode Laser [Mesh] OR (Diode-Driven Laser) OR (Diode Emission Laser))). The search was limited to articles published in English from inception to the present. The inclusion criteria for selected studies were established to encompass research of various evidence levels, excluding only expert opinions. We focused on articles published in English within the past decade, including articles that focused on patients with periodontopathy, specifically those presenting with at least six teeth showing an

interdental probing depth (PD) of  $\geq 5$  mm and a clinical attachment level (CAL) of  $\geq 5$  mm. Exclusion criteria comprised letters to editors, review articles, animal studies, and in vitro research. Studies were also omitted if their full texts were unavailable or inaccessible. Also, any studies lacking information regarding laser settings, clinical protocols, or failing to evaluate at least one of the following were excluded: clinical and radiological data (such as periodontal probing and/or X-rays), microbiological data, or the assessment of postoperative pain.

Two independent reviewers (S.C., G.D.) assessed titles and abstracts to identify potentially relevant studies. Full-text articles were subsequently reviewed for eligibility based on the previously outlined inclusion criteria. Further manual exploration of the references listed in all full-text articles from the electronic search was also conducted. Additionally, a manual search was carried out in the following journals: *Periodontology 2000*, *Clinical Advances in Periodontics*, *Dentistry Journal of Oral Pathology and Medicine*, *Journal of Clinical Periodontology*, *Frontiers in Oral Health*, *International Journal of Periodontics and Restorative Dentistry*, *Lasers in Dental Science*, and *Journal of Periodontal Research*.

From the selected studies, we collected details including authors' names, publication year, country of origin, study design, and patient sample size. Additionally, we recorded the study's objectives, diode laser setting protocols, as well as the conclusions and outcomes reported by the authors. Ethical standards and guidelines for narrative reviews were adhered to throughout this review process [16–22].

### 3. Discussion

#### 3.1. Overview of Surgical Periodontal Therapy

Periodontal surgical therapy plays a critical role in the management of periodontitis, particularly in cases where non-surgical approaches prove insufficient and residual pockets exceed 4–5 mm. This approach focuses on decreasing pocket depths, eradicating harmful bacteria, and reinstating periodontal health. Techniques such as flap surgery, gingivectomy, and regenerative procedures are variably used as adjunctive therapies to enhance access to deep pockets, improve oral hygiene, and facilitate tissue repair. Surgical therapy stabilizes the periodontal condition, reduces inflammation, and helps prevent further tooth loss, leading to more favorable long-term periodontal results [16]. For patients with residual pockets measuring 5 mm following non-surgical periodontal treatment and horizontal bone resorption, resective surgical therapy is one of the therapeutic options to consider, particularly in cases where bone resorption is horizontal and in areas where patient esthetics are not compromised. These pockets may continue to harbor pathogenic bacteria that are difficult to eradicate without surgical intervention [17]. Deep pockets are difficult for patients to clean properly, increasing the risk of ongoing infection, inflammation, and further damage to the periodontal tissues. Resective surgery reduces the depth of these pockets, making it easier for both dental professionals and patients to maintain cleanliness and oral hygiene. Resective periodontal surgery effectively reduces pocket depth, facilitating improved access for both dental professionals and patients to maintain optimal oral hygiene, thereby promoting better long-term periodontal health and stability [17–19]. Several drugs (mainly antibiotics and anti-bacteria) for both systemic and local use have been proposed over time as adjunctive therapies for the basic periodontal protocol for the management of all stages of periodontitis, with the common purpose to reduce/eliminate bacteria contamination and to prevent/delay re-colonization.

Also, considering the well-established laser properties of tissue/surface decontamination, its use in surgical and non-surgical periodontology should theoretically help clinicians

in pathogenic bacteria reduction. Additionally, several authors have described laser use in periodontology for photobiomodulation (alternatively called low-level laser therapy) in combination or not with laser soft tissue surgical treatment, thus exploiting another well recognized property of laser light generally aiming to the reduce tissue inflammation, pain, and promoting faster healing of surgical sites and ulcerated lesions [10,15].

### 3.2. Overview of the Evaluated Studies

The electronic search was completed on 30 May 2024. A total of 603 article titles were reviewed, resulting in the selection of 556 abstracts for further analysis. Consequently, 523 studies were excluded. Articles that involved the use of lasers for non-surgical therapies and all in vitro studies assessing microbiological evidence were not included in this review. Additionally, all articles that discussed the use of lasers in surgical therapy for patients with periodontitis but did not use diode lasers were also excluded. Any studies that failed to detail the laser settings, did not outline the clinical protocols, or did not assess at least one of the following criteria were excluded: clinical and radiological information (such as periodontal probing and/or X-rays), microbiological data, or an evaluation of postoperative pain. In total, 17 articles were then examined in their entirety to determine if they satisfied the inclusion requirements, and eight articles were excluded following further review. Additionally, four more publications that satisfied the inclusion criteria were discovered through manual searching. Subsequently, a total of nine full-text articles were included for data extraction. Two publications evaluated the effects of diode lasers associated with the modified Widman flap. Two other publications examined the use of the diode laser in addition to the Kirkland flap. One article evaluated both the use of the diode laser with the modified Widman flap and in association with the Kirkland flap. Three articles examined the association of the laser with open flap debridement. All these studies evaluated clinical parameters, with one common finding, the assessment of probing depth. Only one study exclusively examined postoperative discomfort and pain during both traditional surgery and in combination with lasers. All studies reported clinical protocols and diode laser setting values. A summary of the comprehensive data extraction is shown in Table 1 [23–31].

**Table 1.** Characteristics and outcomes of the studies included. DL: diode laser.

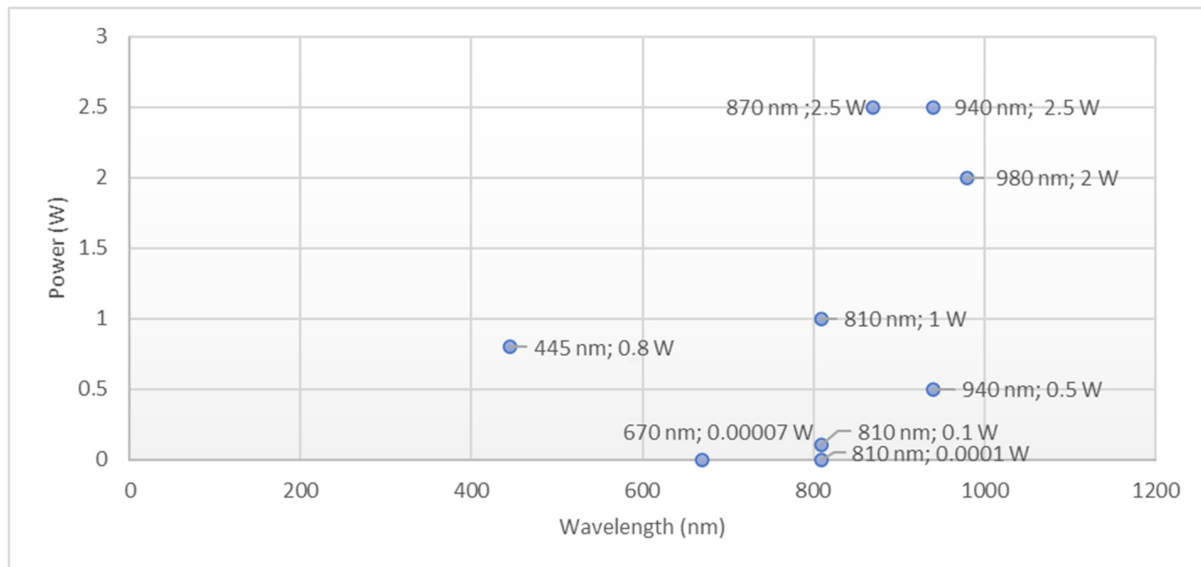
First Author (Year) Country	Study Design—n° Datasets	Aim of the Study	DL Protocols	Outcome or Conclusions
Doğan S. B. et al. (2022) [23]	Randomized Split-Mouth Clinical Trial - 18 patients	To determine the effects of additional application of DL on clinical and microbiological values during modified Widman flap periodontal surgery.	A 810 nm wavelength in continuous wave mode; 1 W (power density 796 W/cm <sup>2</sup> ) was used to lase the inner surface.	At 6 weeks postoperatively, <i>T. denticola</i> , <i>T. forsythia</i> , <i>P. intermedia</i> , and <i>A. actinomycetemcomitans</i> were considerably lower at the test site compared to the control site.
Aena P.J. et al. (2015) [24]	Randomized Split-Mouth Clinical Trial - 25 patients	To compare the clinical efficacy of use of DL as an adjunct to modified Widman flap surgery to that of modified Widman flap alone.	A 810 nm wavelength in continuous wave mode, 30 s at 0.1 W, 45° angle to the soft-tissue flap. A total dosage of 4 J/cm <sup>2</sup> per surface.	DL with a modified Widman flap resulted in probing depth reduction and increased clinical attachment level compared to the control group at 9-month follow-up.

Table 1. Cont.

First Author (Year) Country	Study Design—n° Datasets	Aim of the Study	DL Protocols	Outcome or Conclusions
Karthikeyan J. et al. (2019) [25]	Randomized Split-Mouth Clinical trial - 20 patients	To investigate and compare the clinical and microbiological effects of DL as an adjunct to Kirkland flap surgery versus Kirkland flap surgery alone.	A 970 nm wavelength in continuous wave mode. Power of 2.5 W (power density of 10 W/cm <sup>2</sup> ) and dose of 50 J/cm <sup>2</sup> in contact mode was used by placing the fiber optic tip at a 45° angle to the inner aspect of the flap.	When the DL is used as an adjunct to Kirkland flap surgery, observed reductions in PI, BOP and gains in clinical attachment level (CAL). Additionally, a significant decrease in the levels of periodontal pathogens, such as <i>P. gingivalis</i> , <i>T. denticola</i> , and <i>T. forsythia</i> , has been reported.
Vineet V. et al. (2024) [26]	Randomized Split-Mouth Clinical trial - 13 patients	To assess the clinical efficacy of DL as an adjunct to Kirkland flap surgery in management of periodontitis.	A 445 nm wavelength in continuous wave mode. Power of 0.8 W, 320 µm fiber, in non-contact mode.	VAS scores, indicative of post-surgical discomfort, were lower for the laser-treated sites.
Roy S. et al. (2022) [27]	Randomized Split-Mouth Clinical trial - 10 patients	To evaluate postoperative discomfort and clinical parameters of DL in conjunction with Kirkland flap surgery and modified Widman flap versus these flap surgeries alone.	A 940 nm wavelength in continuous wave mode. Total of 30 s before flap closure, non-contact mode, power of 1.5 W was applied to the inner surface of the flap, exposed bone, and exposed root structures.	A reduction in periodontal tissue inflammation and the mitigation of postoperative pain have been observed when the diode laser (DL) is used.
Martins S.H.L. et al. (2017) [28]	Randomized Split-Mouth Clinical trial - 20 patients	To evaluate the effects of single application of DL photodynamic therapy associated with flap debridement or flap debridement alone.	A 670 nm wavelength in continuous wave mode. Total of 10 s at each site, 70 mW of power (power density of 28 mW/cm <sup>2</sup> , 2.49 J/cm <sup>2</sup> ) with an optic fiber angulated 60, 0.06 mm diameter.	Subgingival plaque samples showed a considerable decrease in pathogen numbers with the use of adjunctive photodynamic therapy.
Dalvi S.A. et al. (2019) [29]	Randomized Split-Mouth Clinical trial - 20 patients	To evaluate the DL antimicrobial photodynamic therapy adjunct to open flap debridement.	A 810 nm wavelength in continuous wave mode. A total of 30 s/DL used, non-contact mode at a power output of 100 mW applied for 30 sec/spot and delivered by 400 µm fiber (0.0125 J/cm <sup>2</sup> per spot, total energy of 3 J).	Photoactivated disinfection improved clinical outcomes when used as an adjunct to open flap debridement in treating chronic periodontitis.
Kolamala N. et al. (2022) [30]	Randomized Split-Mouth Clinical trial - 15 patients	To evaluate and compare the clinical effects and postoperative pain of laser-assisted open flap debridement versus conventional open flap surgery.	A 980 nm wavelength in continuous wave mode. Power setting of 2 W, 320 µm diameter laser tip. No contact with the root surface and alveolar bone by focusing the laser beam 45° towards the flap.	Antimicrobial photodynamic therapy has been shown to enhance clinical outcomes and reduce postoperative pain during the first week following surgery.
Heidari M. et al. (2018) [31]	Randomized Split-Mouth Clinical trial - 30 patients	To evaluate the efficacy of low power of DL on post-operative pain after undisplaced flap surgery.	A 940 nm wavelength in continuous wave mode. Power setting of 0.5 W was applied to the buccal and lingual surfaces of the flap from a distance of 3 mm. Power density of 20 J/cm <sup>2</sup> .	Patient-reported pain levels and analgesic consumption showed a significant reduction following DL-assisted surgery.

### 3.3. Laser Wavelength, Power Settings, and Methods of Use

An important limitation of the current narrative review is surely represented by the wavelengths of laser devices differently used among the studies evaluated, ranging from 445 nm to 980 nm. Additionally, output emission in W ranged from 0.00007 W to 2.5 W, thus including laser use for photobiomodulation alone and the surgical debridement of soft tissues within periodontal pockets. Clearly, a rigid standardization of wavelengths, parameters, and treatment modality of lasers in surgical periodontology is missing nowadays. Figure 1 shows the data of the wavelength settings and power levels of the diode lasers used in all the studies.



**Figure 1.** Wavelength and power level settings used in the studies.

### 3.4. Clinical Outcomes Emerging from the Literature

Considering the aforementioned limitations and the overall data emerging from the studies evaluated in the current narrative review, the clinical outcomes related to the use of diode lasers in periodontal surgical therapy seem to show a general improvement in periodontal parameters, including probing depth (PD), clinical attachment level (CAL), bleeding on probing (BOP), plaque index (PI), and gingival index (GI), with most studies reporting reductions in these values postoperatively ( $p < 0.05$ ) [24,25,27–29,31].

In one study, PD, CAL, BOP, PI, and GI showed no differences between or within groups across follow-up intervals of 6 weeks, 3 months, and 6 months ( $p > 0.05$ ) [23]. Conversely, another study noted significant differences in PBI scores at 6 months ( $p < 0.01$ ) but not at 9 months, with substantial improvements in the test group's PD reduction (64.26%) and CAL gain (81.84%) compared to the control group at 9 months [24]. Additional studies highlighted greater reductions in PD and CAL in test groups at 3 and 6 months, with one study noting a PD reduction of 4.724 mm and CAL gain of 4.689 mm in the test group versus 3.115 mm and 3.147 mm, respectively, in the control group ( $p < 0.001$ ) [25]. Other studies observed similar trends, with the "Kirkland with laser" group achieving the greatest PD and CAL improvements [25–27]. For persistent periodontal pockets ( $PD \geq 5$  mm), test groups showed significantly higher PD reductions at 90 days ( $p < 0.05$ ), though gingival recession (GR) and CAL differences were non-significant [25]. Another study indicated greater CAL gains and faster healing in groups using adjunctive photodynamic therapy ( $p < 0.0001$ ) [28]. Overall, all studies confirmed improvements in periodontal health, with advanced and adjunctive therapies generally yielding superior reductions in PD and gains in CAL, supporting the potential effectiveness of such therapies over time.

### 3.5. Diode Laser and Modified Widman Flap

The modified Widman flap is the most well recognized technique of periodontal resective surgery to manage severe periodontal disease aiming to remove infected tissue and reduce periodontal pockets, thereby improving periodontal tissue health and preventing further tissues loss [32–34]. This surgery is less invasive than traditional periodontal surgery and aims to preserve as much gingival tissue as possible [35]. In this regard, two studies evaluated the outcomes of the Widman flap associated with laser therapy after flap detachment. More precisely, Dogan et al. [23] examined both clinical and microbiological aspects in a sample of 18 patients; PI and GI parameters showed no significant differences in either intra-group or inter-group comparisons at 6 weeks, 3 months, and 6 months postoperatively, while microbiologically, on the other hand, after 6 weeks postoperatively, the quantities of *T. denticola*, *T. forsythia*, *P. intermedia*, and *A. actinomycetemcomitans* were considerably lower at the test sites compared to the controls. Also, Aena PJ et al. [24] evaluated various clinical parameters, particularly PD, BP, and PI, concluding that at baseline, six, and nine months, there was no discernible difference between the two groups of the clinical parameters, while at the conclusion of nine months, the comparison between the diode laser group and the surgical group showed a statistically significant PD reduction. It should be noted that the decrease in PD after periodontal surgery can be primarily related to the effect of gingival resection, and various factors are effective in long-term changes in PD after periodontal surgery. Moreover, all other reported clinical parameters are always similar between the diode laser-treated group and the control group up to the ninth month of follow-up. The reason for the observed decrease in PD therefore cannot be attributed solely to the use of the diode laser during the surgery.

### 3.6. Diode Laser and Kirkland Flap

Among the surgical flaps for periodontal surgery, the Kirkland flap is also a well-known technique used in resective periodontal surgery, similar to the modified Widman flap, although with technical differences in flap setup [36]; technically, this procedure involves a single incision at the gingival margin, which allows the gingival flap to be lifted and for it to access the roots of the underlying teeth, which can be carefully cleaned and smoothed to remove plaque and tartar. In this regard, the study conducted by Karthikeyan et al. [25] analyzed the clinical and microbiological effects of diode lasers as an adjunct therapy to the Kirkland flap surgery compared with Kirkland flap surgery alone; the data collected showed that the adjuvant use of a diode laser resulted in a significant reduction in PI, BOP, and PD, as well as a gain in CAL (clinical attachment loss), and a decrease in the levels of *P. gingivalis*, *T. denticola*, and *T. forsythia*. Although reductions in detailed clinical and microbiological parameters are reported, the statistical significance does not appear to be clearly indicated or sufficiently addressed in this study. The split-mouth design, while useful in reducing inter-individual variability, may not eliminate the potential biological interference between treated and control sites within the same patient, particularly in a small sample size of 20 patients. A distinctive aspect of this study is that the potential cross-contamination of inflammatory or microbiological factors between treated and untreated areas does not appear to have influenced the outcomes.

In a comparison between Widman and Kirkland flaps, both with adjunctive laser use, Roy S. et al. [27] evaluate ten patients randomly assigned to groups A, B, C, and D using the fishbowl lottery method; Kirkland flap surgery with a laser and modified Widman flap surgery with a laser were performed in Groups A and C, respectively, while Kirkland flap surgery and modified Widman flap surgery were performed in Groups B and D, and the clinical parameters, such as the visual analog scale (VAS) score and the level of gingival inflammation, were assessed. The healing process was uneventful in all four groups, and pa-

tients reported no significant complications. The results showed that the implementation of a diode laser as a supplement to periodontal surgery provided significant benefits, improving the overall clinical outcome of treatment and reducing postoperative pain. However, the small size of the effective sample, limited to the number of patients rather than the number of sites, may not provide sufficient statistical power to draw meaningful conclusions.

Four other clinical trials by Martins S.H.L. et al., Dalvi S.A. et al. [29], Kolamala N. et al. [30], and Heidari M et al. [31] examined the effects of antimicrobial photodynamic therapy in the periodontal surgery of patients with chronic severe periodontitis. The authors discuss the use of lasers in association with an open flap debridement procedure. Specifically, the access was performed by an intrasulcular incision of the adjacent teeth of the bone defect. The authors concluded that the postoperative probing depth was significantly reduced by using a diode laser in combination with flap debridement. In addition, Martins S.H.L. et al. [28] further conclude that pathogen levels in subgingival plaque specimens were significantly reduced using laser association, while Kolamala N. et al. [30] and Heidari M et al. [31] further assessed pain perception, concluding that patients treated with lasers, in the week after surgery, had less discomfort and pain compared with the control group.

The lack of sufficient details regarding the methodology employed, such as the criteria for patient inclusion, may limit the reliability of the findings in the aforementioned studies. While reductions in clinical parameters are reported, the statistical significance does not appear to have been thoroughly addressed. Furthermore, the patient selection may not be representative of a broader population, thereby restricting the generalizability of the results.

#### 4. Limitations Emerging from Data Literature Analysis

An analysis of the articles selected for this review revealed the heterogeneity of the protocols used with respect to the use of diode lasers. The operative protocols differ in both the technical settings and clinical application. The utilization of a continuous wave was the one element that connected all the research. The range of wavelengths used in the studies varied from 445 nm to 970 nm. Specifically, one study used a wavelength of 445 nm, one study used 670 nm, three studies employed 810 nm, and four studies utilized wavelengths around 950 nm. The power settings used varied from 70 mW to 2.5 W. The duration of use within the osseous defect also varies among authors, ranging from a minimum of 10 s to a maximum of 30 s. Another notable finding from the present review is the absence of the literature associating the use of diode lasers with regenerative procedures for periodontal defects. Although various adjunctive therapies and solutions are described in the surgical treatment of periodontitis [37,38], there are no studies linking these biomaterials with the use of diode lasers.

Insights from previous literature reviews and in vitro studies are bringing to light the tremendous potential for continuing advancements in laser technology to bring greater precision and effectiveness to periodontal procedures. This may indicate that future innovations in laser systems will be extremely sophisticated devices with advanced control mechanisms, enhanced energy delivery systems, and an optimized range of wavelengths [39]. Such technical improvements are likely to make it possible for lasers to target periodontal tissues with unprecedented specificity, resulting in minimal damage to the surrounding structures, including soft tissues and bone [40].

Besides the improvement in technology, the study also focuses on tailoring laser treatments for each patient's requirements. It may comprise individualized patient-specific factors, including the severity and progression of disease, genetic predispositions, microbiological profiles, and overall systemic health in the design of a treatment protocol. Treatments with such personalized insights using laser technology might enable clinicians to attain maximum therapeutic potential and have the procedures be effective and well

tolerated by patients. This will also be the means to integrate these into clinical practice, possibly changing the management of periodontal diseases, providing healing with less postoperative soreness, and improving long-term successful treatment outcomes [41]. Taken collectively, evidence from the literature and studies in experimental investigations appears to show that this arrival of technology with tailor-made treatment planning can indeed prove a quantum jump in the rendering of periodontal health and benefit both the practitioner and patient immensely [42].

Two limitations of this review include the exclusion of articles not written in English and the possibility of publication bias. Additionally, the quality and variety of the studies included may have influenced the overall conclusions and interpretations. Due to the narrative nature of this review, the synthesis of findings was subjective and not as systematic as in a meta-analysis, which may have led to potential inconsistencies in the interpretation of results. Furthermore, the lack of a standardized tool for assessing the risk of bias across all included studies may have affected the reliability of the conclusions drawn.

## 5. Conclusions

Although the increasing number of studies reflects a growing interest in the use of diode lasers in periodontal surgical therapy, the current narrative review highlights a significant lack of standardization in treatment protocols, thus reflecting a still-persistent uncertainty in the literature, leading to general caution. However, despite variations in surgical techniques and settings, the use of a diode laser as an adjunct in periodontal surgical therapy appears to result in short-term reductions in the plaque index (PI) and bleeding on probing (BOP), as well as gains in the clinical attachment level (CAL). Additionally, a decrease in the levels of periodontal pathogens has been observed. Diode laser use has also been associated with less postoperative discomfort and pain. These results may encourage further investigations into the applications of diode lasers in surgical protocols for periodontics. A more comprehensive evaluation of the effectiveness of diode lasers in periodontal surgery for the treatment of periodontitis necessitates the implementation of well-designed randomized clinical trials conducted under standardized protocols. These studies should include larger and more representative sample sizes, detailed reporting of laser settings and clinical application methodologies, and consistent follow-up periods to allow for the assessment of long-term outcomes and possibly resolve the current limitations emerging from the analysis of the current literature on potentially positive adjunctive effects of the use of diode lasers in surgical periodontology.

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## References

1. Theodoro, L.H.; Marcantonio, R.A.C.; Wainwright, M.; Garcia, V.G. LASER in periodontal treatment: Is it an effective treatment or science fiction? *Braz. Oral Res.* **2021**, *35* (Suppl. S2), e099. [[CrossRef](#)] [[PubMed](#)]
2. Chambrone, L.; Wang, H.L.; Romanos, G.E. Antimicrobial photodynamic therapy for the treatment of periodontitis and peri-implantitis: An American Academy of Periodontology best evidence review. *J. Periodontol.* **2018**, *89*, 783–803. [[CrossRef](#)] [[PubMed](#)]

3. Capodiferro, S.; Limongelli, L.; D'Agostino, S.; Tempesta, A.; Dolci, M.; Maiorano, E.; Favia, G. Diode Laser Management of Primary Extranasopharyngeal Angiofibroma Presenting as Maxillary Epulis: Report of a Case and Literature Review. *Healthcare* **2021**, *9*, 33. [[CrossRef](#)] [[PubMed](#)] [[PubMed Central](#)]
4. Saydjari, Y.; Kuypers, T.; Gutknecht, N. Laser Application in Dentistry: Irradiation Effects of Nd:YAG 1064 nm and Diode 810 nm and 980 nm in Infected Root Canals—A Literature Overview. *BioMed Res. Int.* **2016**, *2016*, 8421656. [[CrossRef](#)] [[PubMed](#)]
5. Nica, D.F.; Heredea, E.R.; Todea, D.C.M. Alveolus soft and bone tissue regeneration after laser biomodulation—A histological study. *Rom. J. Morphol. Embryol.* **2019**, *60*, 1269–1273.
6. Fioravanti, M.; Zara, F.; Voza, I.; Polimeni, A.; Sfasciotti, G.L. The Efficacy of Lingual Laser Frenectomy in Pediatric OSAS: A Randomized Double-Blinded and Controlled Clinical Study. *Int. J. Environ. Res. Public Health* **2021**, *18*, 6112. [[CrossRef](#)]
7. Capodiferro, S.; Maiorano, E.; Scarpelli, F.; Favia, G. Fibrolipoma of the lip treated by diode laser surgery: A case report. *J. Med. Case Rep.* **2008**, *2*, 301. [[CrossRef](#)]
8. Capodiferro, S.; Limongelli, L.; Tempesta, A.; Maiorano, E.; Favia, G. Diode laser treatment of venous lake of the lip. *Clin. Case Rep.* **2018**, *6*, 1923–1924. [[CrossRef](#)] [[PubMed](#)] [[PubMed Central](#)]
9. Scarano, A.; Lorusso, F.; Di Cerbo, A.; Lucchina, A.G.; Carinci, F. Eradication of hairy mouth after oncological resection of the tongue and floor mouth using a diode laser 808 nm. Postoperative pain assessment using thermal infrared imaging. *Lasers Surg. Med.* **2019**, *51*, 516–521. [[CrossRef](#)]
10. Tetè, G.; Ferrante, L.; Moretto, M.; Rellandini, G.; Polizzi, E. The efficacy of the diode laser at 800–980 nm as an aid to non-surgical therapy in periodontitis treatment: A review of literature. *J. Biol. Regul. Homeost. Agents.* **2021**, *35* (Suppl. S1), 51–63. [[CrossRef](#)]
11. Falkenstein, F.; Gutknecht, N.; Franzen, R. Analysis of laser transmission and thermal effects on the inner root surface during periodontal treatment with a 940-nm diode laser in an in vitro pocket model. *J. Biomed. Opt.* **2014**, *19*, 128002. [[CrossRef](#)] [[PubMed](#)]
12. Patel, S.; Awan, K.H.; Freitas, C.M.T.; Bhandi, S.; Licari, F.W.; Patil, S. Diode laser targeting red-complex bacteria in periodontitis: A systematic review. *Eur. Rev. Med. Pharmacol. Sci.* **2023**, *27*, 11806–11816. [[PubMed](#)]
13. Capodiferro, S.; Maiorano, E.; Loidice, A.M.; Scarpelli, F.; Favia, G. Oral laser surgical pathology: A preliminary study on the clinical advantages of diode laser and on the histopathological features of specimens evaluated by conventional and confocal laser scanning microscopy. *Minerva Stomatol.* **2008**, *57*, 1–7. (In Italian) [[PubMed](#)]
14. Yu, S.; Zhao, X.; Zhang, Y.; Liu, Y.; Li, A.; Pei, D. Clinical effectiveness of adjunctive diode laser on scaling and root planing in the treatment of periodontitis: Is there an optimal combination of usage mode and application regimen? A systematic review and meta-analysis. *Lasers Med. Sci.* **2022**, *37*, 759–769. [[CrossRef](#)]
15. Bozkurt, S.B.; Hakki, E.E.; Kayis, S.A.; Dundar, N.; Hakki, S.S. Biostimulation with diode laser positively regulates cementoblast functions, in vitro. *Lasers Med. Sci.* **2017**, *32*, 911–919. [[CrossRef](#)]
16. Haas, A.N.; Furlaneto, F.; Gaio, E.J.; Gomes, S.C.; Palioto, D.B.; Castilho, R.M.; Sanz, M.; Messoria, M.R. New tendencies in non-surgical periodontal therapy. *Braz. Oral Res.* **2021**, *35* (Suppl. S2), e095. [[CrossRef](#)]
17. Khoury, F.; Keeve, P.L.; Ramanauskaite, A.; Schwarz, F.; Koo, K.T.; Sculean, A.; Romanos, G. Surgical treatment of peri-implantitis—Consensus report of working group 4. *Int. Dent. J.* **2019**, *69* (Suppl. S2), 18–22. [[CrossRef](#)]
18. Kwon, T.; Lamster, I.B.; Levin, L. Current Concepts in the Management of Periodontitis. *Int. Dent. J.* **2021**, *71*, 462–476. [[CrossRef](#)]
19. Dommisch, H.; Walter, C.; Dannewitz, B.; Eickholz, P. Resective surgery for the treatment of furcation involvement: A systematic review. *J. Clin. Periodontol.* **2020**, *47* (Suppl. S22), 375–391. [[CrossRef](#)]
20. Shankar Ganesh, G. Narrative approaches to reviews. *Natl. Med. J. India.* **2023**, *36*, 67–68. [[CrossRef](#)]
21. Zaharias, G. What is narrative-based medicine? Narrative-based medicine 1. *Can. Fam. Physician* **2018**, *64*, 176–180. [[PubMed](#)]
22. Gasparyan, A.Y.; Ayvazyan, L.; Blackmore, H.; Kitas, G.D. Writing a narrative biomedical review: Considerations for authors, peer reviewers, and editors. *Rheumatol. Int.* **2011**, *31*, 1409–1417. [[CrossRef](#)] [[PubMed](#)]
23. Doğan, Ş.B.; Akça, G. Clinical Evaluation of Diode Laser-Assisted Surgical Periodontal Therapy: A Randomized Split-Mouth Clinical Trial and Bacteriological Study. *Photobiomodul. Photomed. Laser Surg.* **2022**, *40*, 646–655. [[CrossRef](#)] [[PubMed](#)]
24. Aena, P.J.; Parul, A.; Siddharth, P.; Pravesh, G.; Vikas, D.; Vandita, A. The clinical efficacy of laser assisted modified Widman flap: A randomized split mouth clinical trial. *Indian J. Dent. Res.* **2015**, *26*, 384–389. [[CrossRef](#)]
25. Karthikeyan, J.; Vijayalakshmi, R.; Mahendra, J.; Kanakamedala, A.K.; Chellathurai, B.N.K.; Selvarajan, S.; Namachivayam, A. Diode Laser as an Adjunct to Kirkland Flap Surgery—A Randomized Split-Mouth Clinical and Microbiological Study. *Photobiomodul. Photomed. Laser Surg.* **2019**, *37*, 99–109. [[CrossRef](#)]
26. Vineet, V.; Balaji, S.K.; Krishnakumar, D.; Kumar, D.; Lavu, V. Assessment of clinical efficacy of 445 nm Diode laser as an adjunct to Kirkland flap surgery in the management of periodontitis—A split mouth randomized clinical trial. *Lasers Med. Sci.* **2024**, *39*, 82.
27. Roy, S.; Singh, D.K.; Manohar, B. Comparative evaluation of postoperative pain and tissue response in patients undergoing conventional flap surgeries with or without 940 nm diode laser exposure—A randomized clinical study. *J. Educ. Health Promot.* **2022**, *11*, 417. [[CrossRef](#)]

28. Martins, S.H.L.; Novaes, A.B., Jr.; Taba, M., Jr.; Palioto, D.B.; Messora, M.R.; Reino, D.M.; Souza, S.L.S. Effect of surgical periodontal treatment associated to antimicrobial photodynamic therapy on chronic periodontitis: A randomized controlled clinical trial. *J. Clin. Periodontol.* **2017**, *44*, 717–728. [[CrossRef](#)]
29. Dalvi, S.A.; Hanna, R.; Gattani, D.R. Utilisation of antimicrobial photodynamic therapy as an adjunctive tool for open flap debridement in the management of chronic periodontitis: A randomized controlled clinical trial. *Photodiagnosis Photodyn. Ther.* **2019**, *25*, 440–447. [[CrossRef](#)]
30. Kolamala, N.; Nagarakanti, S.; Chava, V.K. Effect of diode laser as an adjunct to open flap debridement in treatment of periodontitis—A randomized clinical trial. *J. Indian Soc. Periodontol.* **2022**, *26*, 451–457. [[CrossRef](#)]
31. Heidari, M.; Fekrazad, R.; Sobouti, F.; Moharrami, M.; Azizi, S.; Nokhbatolfoghahaei, H.; Khatami, M. Evaluating the effect of photobiomodulation with a 940-nm diode laser on post-operative pain in periodontal flap surgery. *Lasers Med. Sci.* **2018**, *33*, 1639–1645. [[CrossRef](#)] [[PubMed](#)]
32. Heitz-Mayfield, L.J.; Trombelli, L.; Heitz, F.; Needleman, I.; Moles, D. A systematic review of the effect of surgical debridement vs non-surgical debridement for the treatment of chronic periodontitis. *J. Clin. Periodontol.* **2002**, *29* (Suppl. S3), 92–102; discussion 160–162. [[CrossRef](#)]
33. Ramfjord, S.P.; Nissle, R.R. The modified widman flap. *J. Periodontol.* **1974**, *45*, 601–607. [[PubMed](#)]
34. Ramfjord, S.P. Present status of the modified Widman flap procedure. *J. Periodontol.* **1977**, *48*, 558–565. [[CrossRef](#)] [[PubMed](#)]
35. Retzepi, M.; Tonetti, M.; Donos, N. Comparison of gingival blood flow during healing of simplified papilla preservation and modified Widman flap surgery: A clinical trial using laser Doppler flowmetry. *J. Clin. Periodontol.* **2007**, *34*, 903–911. [[CrossRef](#)]
36. Kumar, A. An Ode to Kirkland flap. . . Obituary to Modified Widman flap. *J. Indian. Soc. Periodontol.* **2018**, *22*, 373–374. [[CrossRef](#)]
37. D’Albis, G.; D’Albis, V.; Palma, M.; Plantamura, M.; Nizar, A.K. Use of hyaluronic acid for regeneration of maxillofacial bones. *Genesis* **2022**, *60*, e23497. [[CrossRef](#)]
38. Nuñez, J.; Vignoletti, F.; Caffesse, R.G.; Sanz, M. Cellular therapy in periodontal regeneration. *Periodontol. 2000* **2019**, *79*, 107–116. [[CrossRef](#)]
39. Huang, Q.; Li, Z.; Lyu, P.; Zhou, X.; Fan, Y. Current Applications and Future Directions of Lasers in Endodontics: A Narrative Review. *Bioengineering* **2023**, *10*, 296. [[CrossRef](#)]
40. Ohsugi, Y.; Hatasa, M.; Katagiri, S.; Hirota, T.; Shimohira, T.; Shiba, T.; Komatsu, K.; Tsuchiya, Y.; Fukuba, S.; Lin, P.; et al. High-frequency pulsed diode laser irradiation inhibits bone resorption in mice with ligature-induced periodontitis. *J. Clin. Periodontol.* **2022**, *49*, 1275–1288. [[CrossRef](#)]
41. Talmac, A.C.; Yayli, N.Z.A.; Calisir, M.; Ertugrul, A.S. Comparing the efficiency of Er,Cr:YSGG laser and diode laser for the treatment of generalized aggressive periodontitis. *Ir. J. Med. Sci.* **2022**, *191*, 1331–1339. [[CrossRef](#)]
42. Giannelli, M.; Materassi, F.; Fossi, T.; Lorenzini, L.; Bani, D. Treatment of severe periodontitis with a laser and light-emitting diode (LED) procedure adjunctive to scaling and root planing: A double-blind, randomized, single-center, split-mouth clinical trial investigating its efficacy and patient-reported outcomes at 1 year. *Lasers Med. Sci.* **2018**, *33*, 991–1002.

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